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EVALUATION OF QUALITY OF AQUATIC HABITAT ON THE NITRICA RIVER

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Abstract. The article is focused on the process of evaluation of the quality of aquatic habitats. The habitat quality is characterized by bioindication, which is represented by ichtyofauna in habitat suitability curves. During the periods of minimum flows the ichtyofauna prefers covers with deeper habitats. This has been showed by the correlation of suitability curve characteristics for water depth. The curves are based on the frequency sorting of the fish in microhabitat, which were determined on the basis of the ichtyological survey. Accuracy assessment of the suitability curves is one of the most important steps in the IFIM methodology. Evaluation and generalization of the suitability curves for Schneider (*Alburnoides bipunctatus*) was done in the Nitrica River. The suitability curves were processed for two abiotic parameters – depth and velocity.

Hydraulic and ichthyologic measurements were performed in summer 2013. The morphology of the Nitrica River was measured for needs of 2D hydraulic modeling, which was performed by 2D model DHI MIKE 21FM. The results of weighted usable area show that the Schneider prefers minimum range of flows.

Key words: IFIM, 2D hydraulic model, Weighted Usable Area (WUA), suitability curve, Schneider

INTRODUCTION

Nowadays, the negative effects of human activities on rivers can be easily identified. This is the reason for the current need to restore the unfavourable state of rivers, but with regard to the essential needs of mankind [Neruda et al. 2012].

Evaluation of the quality of aquatic habitat is based on the river morphology in connection with the quality of water and biotic interaction [Mazeika et al. 2006]. The anthropogenic activities have a great influence on the mentioned river characteristics. This is the reason for a systematic and repeatable analysis of river characteristics of habitat for exact

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modelling of biological parameters. Nowadays, the specialized models can be used to evaluate the quality of microhabitat [Bockelmann et al. 2004, Belcakova 2012].

For this analysis decisions making systems based on principles of Instream Flow Incremental Methodology (IFIM) are usually used. Two main fields are used by this methodology: abiotic field and biotic field. The abiotic field included river morphology, river roughness, velocity field, depth of water in specific discharge. The biotic field is based on fish as the best bioindicator. The fish are the best bioindicator, because they are very sensitive on changes in river morphology [Macura et al. 2009, Lasne et al. 2007]. The long life and mobility ability of the fish are intended as an excellent parameters for bioindication [Welcomme et al. 2006, Belcakova 2005].

MATERIALS AND METHODS

The references reach of the Nitrica River

The river Nitrica is a tributary of Nitra River. Total length of river Nitrica is 54.1 km and the catchment is 319 km^2. The spring area of river Nitrica is located in 760 m, between two hills Homolka (906.6 m) and Vapec (955.5 m). Nitrica River is located in 800–200 meters above sea level.

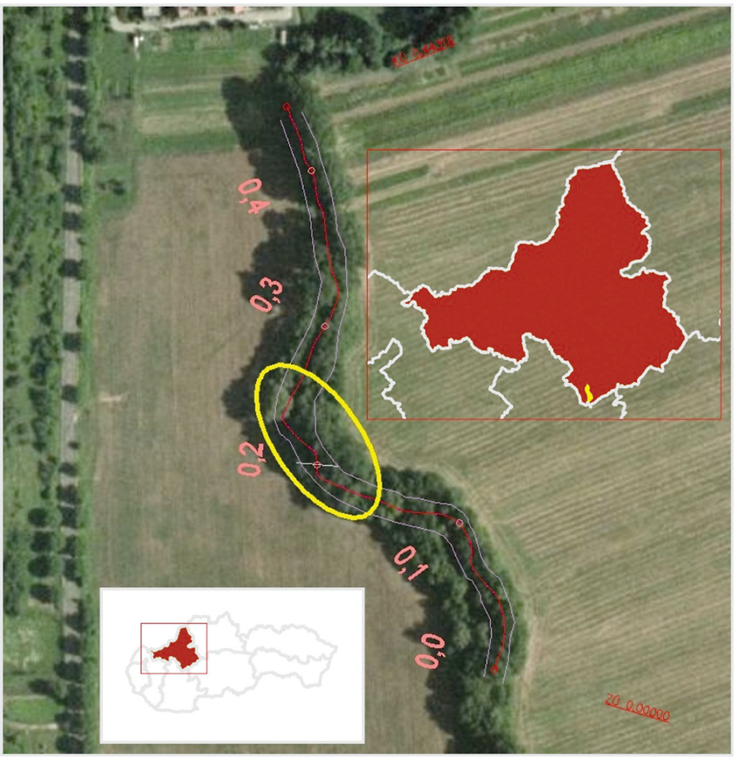

Fig. 1. Reference reach of the Nitrica River

The chosen part of the Nitrica River is located at the end of village Jeskova Ves. The chosen part has total length of 400 m (Fig. 1). For detailed analysis of the quality of aquatic habitat one place in the middle of the reference area was chosen.

This part of the Nitrica River has natural character, with a significantly recessed channel. The dissected morphology of channel makes suitable conditions for fish life. Bed of the channel is built by gravel and big stones. Partial shading to full shading of water level is caused by riparian vegetation. Roots of trees and shrubs make suitable microhabitats for fish.

Materials

- Network of characteristic points to create morphology of the stream channel in 2D hydraulic model. The field measure was done between 12–14 September 2013.
- Characteristic of ichtyofauna according to work of Stankoci [2013].
- The measurement by the current meter was done in 12 September 2013.

Methods

- Calculation of hydraulic parameters by 2D hydraulic model.
- Assigning values of suitability of hydraulic parameters.
- Calculation of Combined suitability factor – geometric average.

RESULTS AND CONCLUSION

Calculation of hydraulic parameters by 2D hydraulic model

1D hydraulic model calculates the hydraulic parameters based on stream cross-sections, however the characterization of river by stream cross-sections have many limits. For example, the directional of flow routing were not taken into account within the results of hydraulic calculated according to 1D hydraulic model. The next disadvantage is huge area of cells, which was caused by generalization between two stream cross-sections. In contrast, the 2D hydraulic models are able to make detailed characterization of the directional of flow routing.

2D hydraulic model MIKE 21 FM (flexible mesh) was used for calculation the hydraulic parameters. The network of characteristic points of morphology and results from discharge measurements by current meter were used as input into hydraulic model. Next, in software MIKE the calculating network of points was built. Measured parameters were imported into this calculating network of points. The network of points was used as a base for hydraulic model. As an initial condition of discharge the value of 270 m-day discharge ($0.23\ m \cdot s^{-1}$) was set. This value was measured by the field measurements.

The results from hydraulic model MIKE 21 FM were calculated in a form of time steps. For each point of the network value of total water depth and mean velocities in verticals were calculated. The first three time steps show continuously filling the hydraulic model by water. The next time steps show fixing the value of hydraulic parameters. The tenth time step indicates a steady flow. This time step was chosen for the next analysis. Values of total water depth and mean velocities in verticals are visible in Fig. 2 and 3.

The Fig. 2 – Total water depth, shows the results of water depth in each place. The red areas show maximum values. The maximum value of water depth was calculated above 1.3 m.

The Fig. 3 – Mean velocity in verticals, shows the results. The same colour scale was used. The maximum value of mean velocity in verticals was calculated above 1 m · s^{-1}. The areas with the highest value of mean velocity in verticals are located in fords.

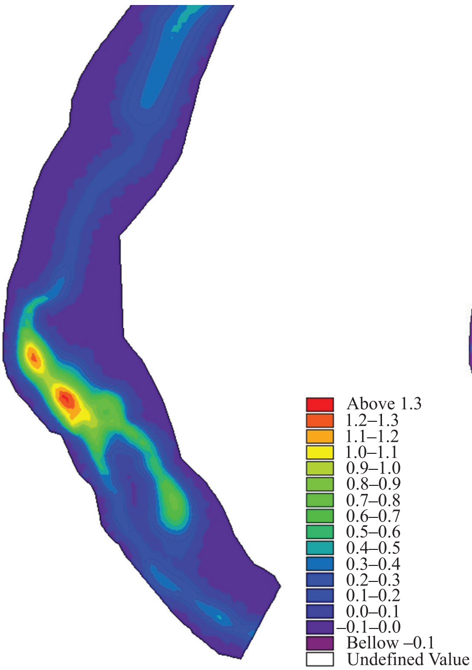

Fig. 2. Total water depth, m

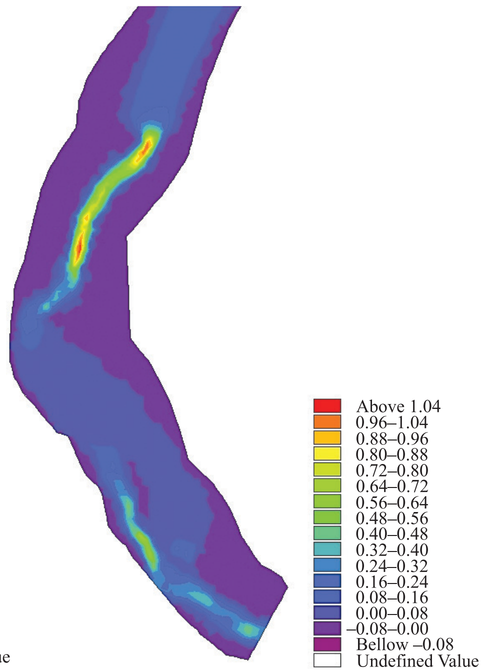

Fig. 3. Mean velocities in verticals, m · s^{-1}

Assigning the values of the suitability of hydraulic parameters

The suitability of two abiotic parameters, especially water depth and mean velocity in vertical, were published in work of Stankoci [2013]. Stankoci [2013] did the ichthyologic survey on the same reference reach of the Nitrica River. Suitability curves for water depth and mean velocity in vertical were based on the ichthyologic survey.

The creating of these suitability curves is a complicated process in IFIM methodology. The significant factor in creating of suitability curves the number of fish, because the seriousness of curves is increasing by increasing the number of fish. If the number of fish is low, the suitability curves are inapplicable. As a bioindicator the fish species Schneider (*Alburnoides bipunctatus*) was chosen, because during the ichthyologic survey, there have been enough the number of this kind of fish. This kind of fish is representative for evaluation of aquatic habitat on the Nitrica River. The suitability curves are shown in Fig. 4 and Fig. 5.

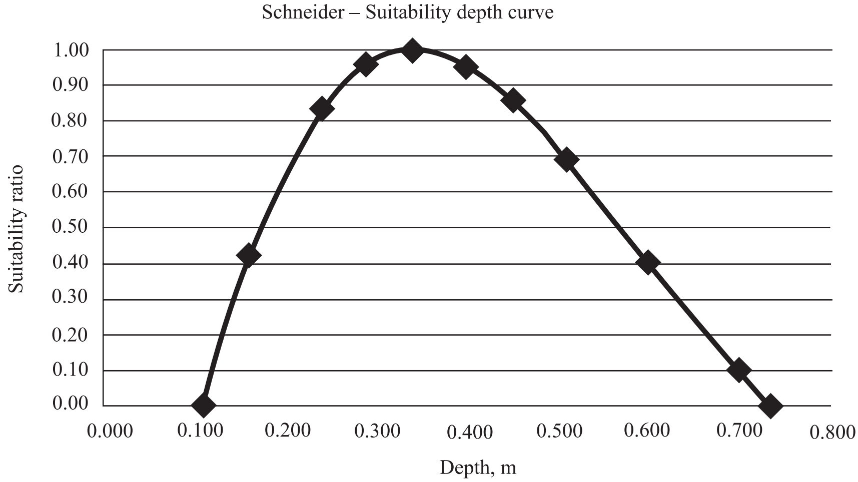

Fig. 4. Suitability depth curve, m. *Source*: Stankoci 2013

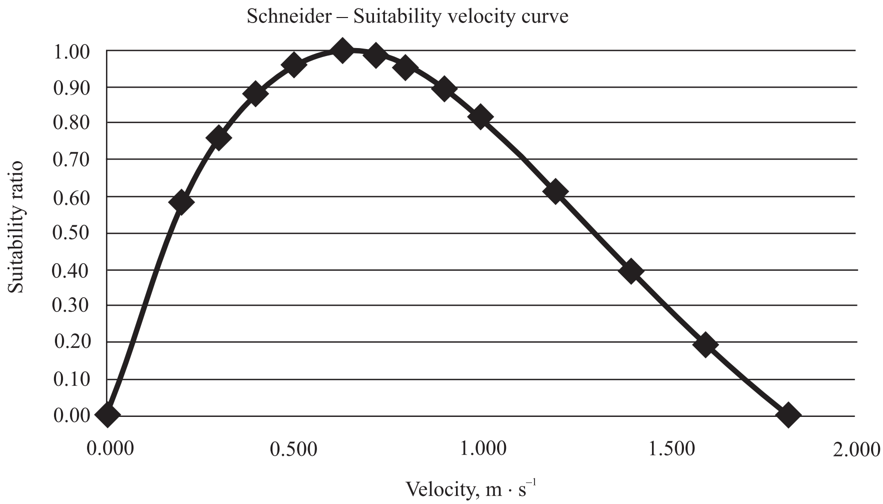

Fig. 5. Suitability velocity curve, m · s^{-1}. *Source*: Stankoci 2013

Figure 4 suitability curve for the depth, for the fish species Schneider (*Alburnoides bipunctatus*), shows an increasing of the suitability from 0.10 m to 0.35 m and decreasing of suitability from 0.35 m to 0.75 m.

Figure 5 suitability curve for the velocity, for the fish species Schneider (*Alburnoides bipunctatus*), shows an increasing of the suitability from 0.00 m · s^{-1} to 0.60 m · s^{-1} and decreasing of suitability from 0.60 m · s^{-1} to 1.80 m · s^{-1}.

Both of these suitability curves were defined by polynomial trendline for the next analysis in GIS environment. The following step, the suitability curves were used for assigning the values of the suitability to calculated the parameters from 2D hydraulic model. The results are shown on Fig. 6 and Fig. 7.

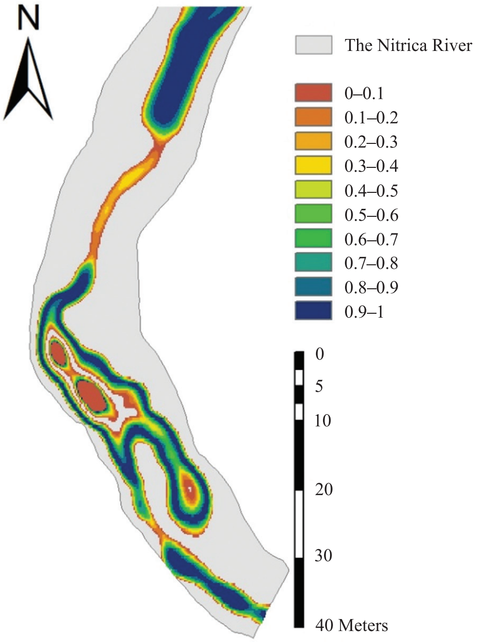

Fig. 6. Suitability of depth

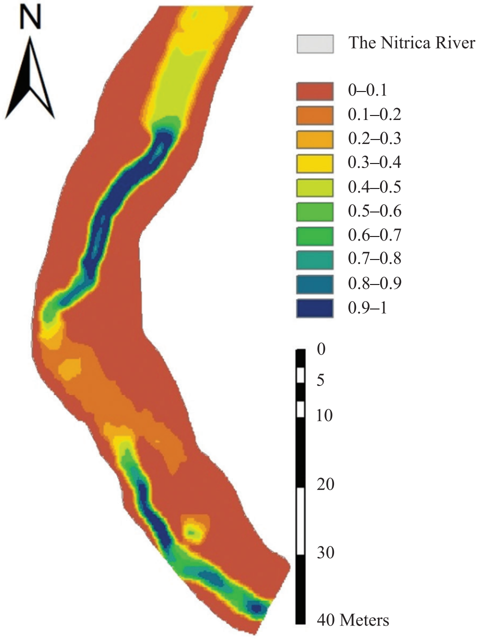

Fig. 7. Suitability of velocity

The suitability for the depth parameter or velocity parameter in an area is shown by the colour scale. The same colour scale was used for both figures. The better suitability of parameter is, the darker the colour is.

Calculation of Combined suitability factor

The result values of combined suitability factor are more detailed, because in this case there was used 2D hydraulic model. The GIS environment was used for the next analysis of results that came from the 2D hydraulic model. The GIS environment was helpful in a detailed analysis, because it has many tolls to specify the application of suitability curves. According to these possibilities, we did a great progress in an evaluation of the quality of aquatic habitat.

The Combined suitability factor can be calculated by many ways. The calculation based on geometric average was chosen for this study. The following formula was used in this study:

$$CSF = (P_v \cdot P_h)^{\frac{1}{P_v + P_h}}$$

Where:

CSF – combined suitability factor
P_v – velocity suitability index
P_h – depth suitability index

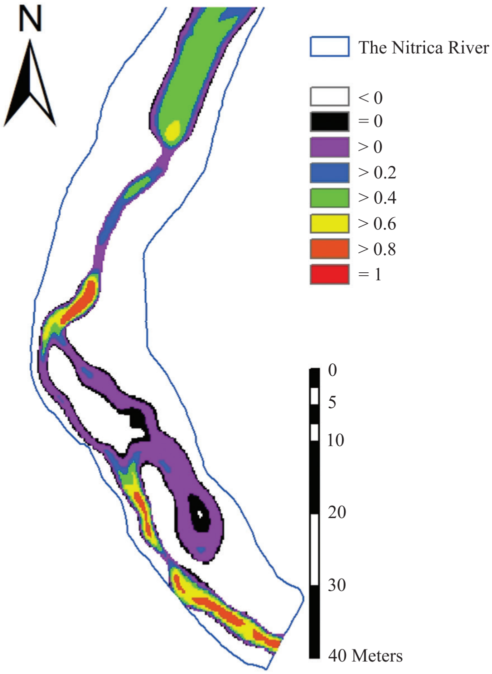

Fig. 8. Combined suitability factor – geometric average

The results of combined suitability factor are shown on Fig. 8. The Fig. 8 – Combined suitability factor – geometric average, contains places without any suitability are indicated by a white colour. Other places that are better for the bioindicator are displayed by following colours. The best quality of aquatic habitat is shown by red colour. These areas are suitable for living of the bioindicator Schneider (*Alburnoides bipunctatus*).

In the Fig. 8, there can be seen a white hollow area. In this area, the water is indicated by 2D hydraulic model. However this area has a depth of water above 0.75 m, and is out of the range of the depth suitability curve.

This is the most suitable reason for additional development in a shape of suitability curves. The next generation of suitability curves should take into account values of parameters, which are out of range in today's suitability curves.

SUMMARY

Detailed description of river morphology was done as the first step. The special geodetic equipment was used for this description. The result from field measurement was network of characteristic points. This network was used for creating the river morphology in software MIKE 21 FM. Meanwhile, the measurement of currently flow was done. The result value of discharge was 0.23 $m \cdot s^{-1}$. This is value of 270 m-day discharge in the Nitrica River and it was set up as initial condition for 2D hydraulic model. After calculation in software MIKE 21 FM we received values of total water depth and mean velocities in verticals. These values were compared with characteristic of ichtyofauna according to work of Stankoci [2013]. Later these results were used to calculating combined suitability index. The relevance of combined suitability index calculated by 2D hydraulic model is much more better and detailed, as results comes from 1D hydraulic model.

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OCENA JAKOŚCI ŚRODOWISKA WODNEGO W RZECE NITRICA

Streszczenie. Autor pracy skoncentrował się na procesie oceny środowisk wodnych. Jakość środowiska charakteryzuje się poprzez bioindykację, która jest reprezentowana przez krzywe przydatności ichtiofauny w środowisku. Podczas okresów minimalnych przepływów ichtiofauna preferuje przebywanie w środowiskach na większej głębokości. Pokazuje to korelacja właściwości krzywej przydatności dla głębi wodnej. Krzywe sporządzono w oparciu o uporządkowanie częstotliwości ryb w mikrośrodowisku, które były określane na podstawie badań ichtiologicznych. Ocena dokładności krzywych przydatności jest jednym z najważniejszych kroków w metodologii IFIM. Ocena i uogólnienie krzywych przydatności dla gatunku Schneider (*Alburnoides bipunctatus*) została wykonana w rzece Nitrica. Krzywe przydatności były przygotowane w oparciu o dwa parametry nieożywione: głębokość i prędkość. Pomiary hydrauliczne i ichtiologiczne przerowadzono w lecie 2013 r. Morfologia rzeki Nitrica została zmierzona na potrzeby modelowania hydraulicznego 2D, wykonanego przy użyciu modelu 2D DHI MIKE 21FM. Wyniki ukierunkowanego obszaru użytkowego pokazują, że Schneider preferuje minimalny zakres przepływów.

Słowa kluczowes: IFIM, model hydrauliczny 2D, Ukierunkowany Obszar Użytkowy (Weighted Usable Area [WUA]), krzywa przydatności, Schneider

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